

Maternal mortality in a rural district of southeastern Tanzania: an application of the sisterhood method

F Font,^a M Alonso González,^a R Nathan,^b F Lwilla,^b J Kimario,^b M Tanner^c and PL Alonso^a

Background	Deaths from maternal causes represent the leading cause of death among women of reproductive age in most developing countries. It is estimated that the highest risk occurs in Africa, with 20% of world births but 40% of the world maternal deaths. The level of maternal mortality is difficult to assess especially in countries without an adequate vital registration system. Indirect techniques are an attractive cost-effective tool to provide estimates of orders of magnitude for maternal mortality.
Method	The level of maternal mortality estimated by the sisterhood method is presented for a rural district in the Morogoro Region of Southeastern Tanzania and the main causes of maternal death are studied. Information from region-specific data using the sisterhood method is compared to data from other sources.
Results	The maternal mortality ratio (MMR) was 448 maternal deaths per 100 000 live births (95%CI : 363–534 deaths per 100 000 live births). Maternal causes accounted for 19% of total mortality in this age group. One in 39 women who survive until reproductive age will die before age 50 due to maternal causes. The main cause of death provided by hospital data was puerperal sepsis (35%) and postpartum haemorrhage (17%); this is compatible with the main causes reported for maternal death in settings with high levels of maternal mortality, and similar to data for other regions in Tanzania. The sisterhood method provides data comparable with others, together with a cost-effective and reliable estimate for the determination of the magnitude of maternal mortality in the rural Kilombero District.
Keywords	Maternal mortality, sisterhood method, demography, Tanzania, risk
Accepted	28 May 1999

Deaths from maternal causes represent the leading cause of death among women of reproductive age in most developing countries.¹ Of the estimated 585 000 annual deaths worldwide due to complications of pregnancy and delivery, 99% occur in the developing world.² It is estimated that the highest risks from pregnancy occur in Africa, in particular in Eastern and Western Africa, with ratios over 1000 maternal deaths per 100 000 live births.³

The establishment of quantitative goals for reduction in maternal mortality by the global Safe Motherhood Conference in 1987 and the 4th World Conference on Women in 1995 increases the pressure on governments to provide more accurate estimates of maternal mortality. However, maternal mortality is difficult to assess for various reasons. First of all, a maternal death is a somewhat infrequent event; even in areas with high

ratios the absolute number of maternal deaths is relatively low. Secondly, maternal deaths tend to be underreported and/or misclassified even in countries with a satisfactory vital registration system.^{4–6} In most developing countries vital registration systems are incomplete and correct attribution of cause of death is the exception. In such settings, other approaches are needed to estimate the level of maternal mortality. The recognized gold standard for estimating maternal mortality are reproductive age mortality surveys (RAMOS)⁷ but they are complex and costly to conduct. Household surveys using direct estimation require very large sample sizes to provide reliable and representative results, the confidence intervals for estimates are typically wide and maternal mortality indicators are therefore imprecise. The WHO/UNICEF estimates try to compensate for problems of underreporting and misclassification. The method involves a dual strategy: (1) where maternal mortality estimates already exist, the figures are adjusted to account for underreporting and misclassification; (2) where no reliable estimates are available, a model based on fertility rates and the proportion of births that are assisted by skilled personnel generates an estimated figure.

^a Epidemiology and Biostatistics Unit, Hospital Clinic, Barcelona, Spain.

^b Ifakara Health Research and Development Centre, Ifakara, Tanzania.

^c Swiss Tropical Institute, Basle, Switzerland.

Table 1 Sources and estimates of maternal mortality for Tanzania and Morogoro region

Sources	Reference date	MMR ^a (deaths per 100 000 live births)
National estimates		
Tanzanian Bureau of Statistics ^b	1988	197
WHO ^c	1990	770
World Bank ^d	1988	342
Monitoring Health for All exercise	1990–1991	209
Morogoro region estimates		
Tanzanian Bureau of Statistics ^b	1988	199
Adult morbidity and mortality population study ^e	1997	977 (95% CI : 794–1202)
Kilombero district estimates		
Kilombero district hospital	1991	414
Kilombero district hospital	1992	595
Kilombero district hospital	1993	214

^a Maternal mortality ratio.^b Ref.⁹^c Ref.¹⁰^d Ref.¹¹^e Ref.¹⁸

These estimates have wide margins of error and should be seen as providing orders of magnitude only. In the sisterhood method, an indirect method, a sample of women aged 15–49 is asked to state how many of their sisters have reached the age of 15 and how many of these have died while pregnant, in childbirth or puerperium. The method does not provide an estimate of current maternal mortality levels and is subject to margins of error that relate to sample size. It is, however, considerably more cost-effective than household surveys using direct estimation and can provide estimates of orders of magnitude of the maternal mortality level. These estimates can be used to gain a general sense of the size of the problem, sensitize policy makers, stimulate discussion and action as well as mobilize national and international resources for maternal health.⁸

In Tanzania, maternal mortality ratio (MMR) estimates from national and international sources differ substantially. Values range from 197 to 770 per 100 000 live births for the last decade^{9–11} (Table 1). For the Morogoro region the available estimates also have wide ranges, yielding values of 190 to 977 per 100 000 live births. For the Kilombero District, a rural district in the Morogoro region, the only current source of maternal death data is the District hospital, where only 30% of the deliveries occur.¹² Moreover, variation in figures from year to year in the district hospital's MMR make them unacceptable as a valid estimate for the district (Table 1). Given the lack of consistent estimates to aid health policy and district management, this paper reports the maternal mortality risk and MMR for Kilombero District obtained with the sisterhood method, as well as the main causes of maternal deaths.

Materials and Methods

Study area and population

The study was carried out in the Kilombero District, Morogoro Region, in Southeastern Tanzania (08°9'S 36°40'E). The characteristics of the area and of the Health Care System have been described elsewhere.¹³ In brief, most villagers are subsistence farmers, growing rice, maize and cassava, with

increasing numbers of small traders. Houses mainly have thatched roofs and mud walls and often have inadequate water supply and poor waste disposal. In addition to a small number of private health centres, government health facilities for the district population, which in 1996 was estimated about 187 900, include the St Francis Designated District Hospital (SFDDH) a 375-bed hospital, the adjacent Mother and Child Health clinic, two health centres and 13 dispensaries.

Indirect estimation of maternal mortality

Maternal mortality is expressed through the MMR and the life-time risk of maternal death. The former is the risk of maternal death among pregnant and recently pregnant women. The life-time risk of maternal death is a combined risk expressing the risk of becoming pregnant and that of maternal death faced by a woman over her entire reproductive life span.

Maternal mortality was estimated with an indirect technique termed the sisterhood method. This involves surveying individuals in reproductive age and questioning them about all sisters that have reached reproductive age and which of these have died while pregnant, during childbirth or in the puerperium.

Sample for the sisterhood method survey

The sample size calculation was based on the following premises: (1) The reference sizes established by the authors of the method.¹⁴ Samples of 3000 to 6000 adults are recommended while other authors define as acceptable a sample size of 2500 to 3000 respondents.¹⁵ (2) The number of deaths needed to estimate the MMR, with a specific margin of error is calculated from Equation 1, $r \geq z_{\alpha/2}^2 * (100/\%ME)^2$, (where r = number of deaths needed to estimate the MMR and %ME = percentage margin of error) with 95% CI and a 20% margin of error, the equation leads to a required number of at least 97 deaths. Empirically, from other published studies in similar settings, to detect 97 deaths with an estimated MMR of about 500 per 100 000 live births, the sample size needed is 3200 respondents.¹⁶

Table 2 Maternal mortality estimates for Kilombero district from the survey carried out in July–September, 1995

Age groups	No. respondents	Sisters exposed to risk (N)	Maternal deaths (d)	Adjustment factor (a) ^b	Exposing units (B)	Lifetime risk of dying (q), (CI 95%)	Probability of survival (p = 1 – lifetime risk of dying)
(i)		N(i)	d(i)	a(i)	B(i) = a(i)*N(i)	q(i) = d(i)/B(i)	p(i) = 1 – q(i)
15–19	1039	2306.3 ^a	12	0.107	247	0.05 (0.075–0.022)	0.9514
20–24	1014	2250.8 ^a	15	0.206	464	0.03 (0.048–0.016)	0.9676
25–29	907	1868.0	22	0.343	641	0.03 (0.048–0.020)	0.9657
30–34	659	1529.0	16	0.503	774	0.02 (0.031–0.011)	0.9793
35–39	503	1171.0	21	0.664	778	0.03 (0.038–0.016)	0.9730
40–44	311	711.0	8	0.802	570	0.01 (0.024–0.004)	0.9860
45–49	301	672.0	11	0.9	605	0.02 (0.029–0.008)	0.9818
Total	4734	10 508 (ΣN(i))	105 (Σd(i))	1 (Σa(i))	4073(ΣB(i))	0.026 (Σd(i)/ΣB(i)) (0.031–0.021)	0.9743

Total fertility rate = 5.81.

^a Adjusted by multiplying mean number of sisters in older age groups (2.22) by the number of respondents in each younger age group. Unadjusted values were 1548 for age group 15–19; and 1816 for age group 20–24.

^b Adjustment factors derived by Ref.¹⁴

Women of childbearing age represent about 20% of the total population for the district, i.e. about 37 500 women. Allowing for population growth of 2.6%⁶ per annum and for non-response we decided on a sample of 5250 women obtained by simple one-stage cluster sampling. From a list of 2027 Balozi (the administrative leader of a group of approximately 10 families) 350 ten-cell leaders were selected and all women aged 15–49 from the households corresponding to this leader were interviewed. Older women were not chosen due to memory recall problems and to have more recent time location estimates.

The survey and questionnaire

Structured interviews collected data on: age of the respondent; the number of adult sisters (>15 years), not including herself, born to the same mother, the respondent ever had; the number of these sisters who were still alive; the number of these sisters who had died and the number of these sisters who died during pregnancy, during delivery or within 6 weeks after the end of the pregnancy. Complete birth histories of the participants were obtained by asking the number of children born and the year of birth of each child.

After a period of training and piloting of questionnaire, data collection was carried out from mid July to the end of September 1995. Field supervision and data validation were carried out during the data collection by two senior investigators. Women that were absent from the household were re-visited to minimize non-response.

The following elements were calculated: (1) Total fertility rate (TFR) obtained from the complete birth histories of the women interviewed in the survey. (2) The proportion of adult sisters who had died from maternal causes among the sisters that reached childbearing age. This proportion at age (i) is associated, using adjustment factors,^a with the probability of dying of maternal causes between the age of first risk exposure and age (i) (Table 2).

^a The adjustment factors were developed by the combination of a maternal mortality model with a fixed distribution of differences between the ages of sisters and respondents. This assumes that the parameters of location and shape are similar for all populations, and that the differences between age of sisters and respondent tend to 0. In this way lifetime risks (q) can be translated into the probability of survival (p), as indicated in equation (2). $p = 1 - \text{lifetime risk of dying}$.

The MMR, derived from the probability of survival (p) and the total fertility rate (TFR), as depicted in Equation 3: $\text{MMR} = 1 - [(p)^{1/\text{TFR}}]$. The MMR is very sensitive to the total fertility rate and minor changes in the TFR may produce substantial difference in MMR.

The number of sisters of childbearing age for the two lower age groups were obtained by multiplying the number of respondents in those age groups by the average number of sisters in the older age (25–49) groups. For example, if the average number of sisters the women aged 25–49 have is 2.219, then the expected number of sisters that 1039 women (aged 15–19) would have is 2.219×1039 , i.e. 2306 women.

The time period to which the estimate refers is not directly visualized since the method uses retrospective data on deaths. The time period was estimated through Equation 4: $T = \Sigma (T(i) \cdot B(i)) / \Sigma B(i)$, where T = the point time location of the global estimate, T(i) = the time location of the estimate for each age group and B(i) = the exposing units of each age group.

The 95% CI were obtained for ratios using standard error formulae refined by Hanley *et al.*¹⁶

An approximation to the proportion of maternal deaths to all deaths in this age group was estimated from the number of maternal deaths declared relative to the total number of deaths.

Information on causes of maternal death was obtained from the clinical histories of death of women of childbearing age at the SFDDH and the live births in SFDDH for the last years available, 1991 to 1993.

Data were processed with SAS (SAS Institute Inc., Carey, NC, USA) and Microsoft[®] Excel 97 SR-1.

Results

In all, 4734 women were interviewed, (91% of the sampling frame). The average number of sisters for women aged 25–49 is 2.22 (2681/5951). The district total fertility rate (TFR) for 1979–1989 was 5.8, with a mean age of childbearing of 27.7 years.

A total of 10 507 sisters reached the age of 15 years, including the 558 now dead. Maternal causes accounted for 19% of total

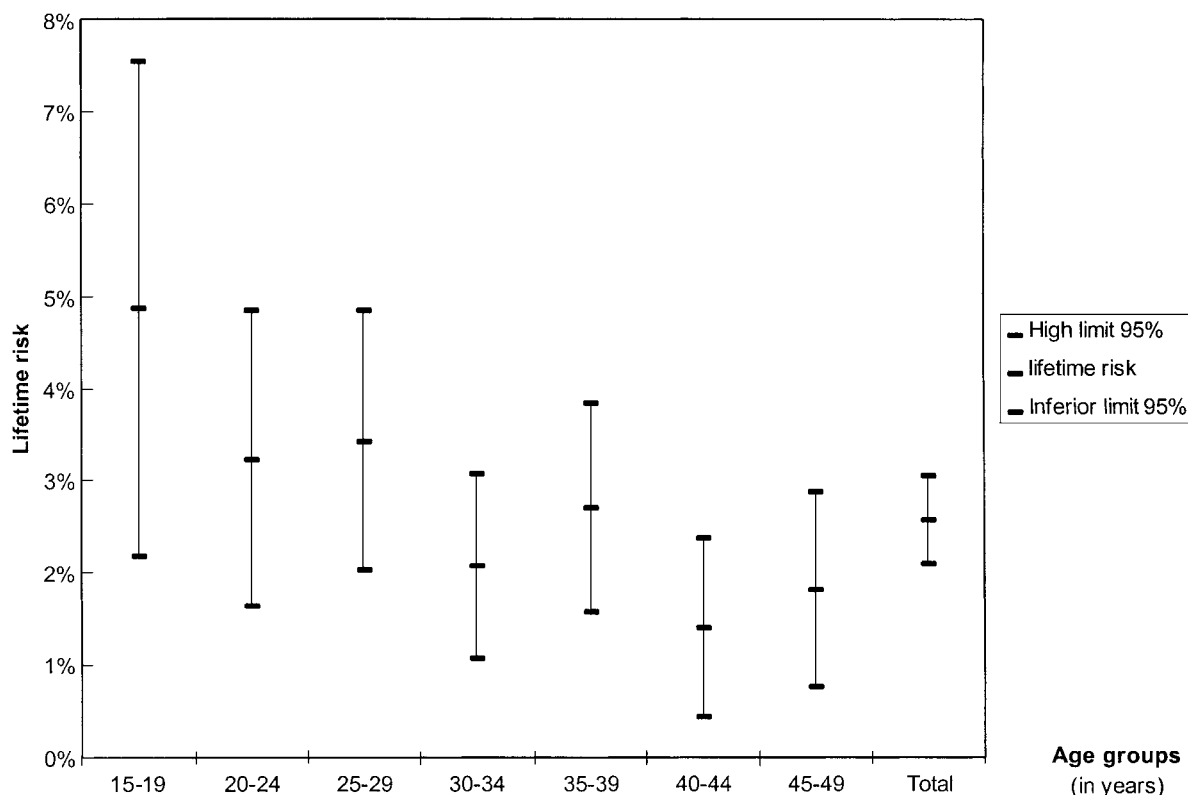


Figure 1 Maternal lifetime risks of death, by age group, for Kilombero District

mortality in women in reproductive age (105/558) (Table 2). The lifetime risk of dying due to maternal causes (q) was 0.026 (95% CI: 0.021–0.031) (Table 2), i.e. 1 in 39 women 15–49 years old. The maternal mortality ratio is 448 maternal deaths per 100 000 live births ($1 - (0.9743^{1/5.8}) * 100\ 000$), (95% CI: 363–534 deaths per 100 000 live births).

The lifetime risks between age groups are relatively stable and declining (Table 2 and Figure 1). No higher risk at older ages is shown. The lower age groups (15–19 years), however, have very wide CI and values higher than the rest. However, when the younger age groups were not taken into account, the total MMR calculated using the more stable age group estimates (ages 20–49) was 422 per 100 000 live births (95% CI: 337–508 per 100 000 live births), a value similar to the previous results.

The estimate refers to 1980–1990, the older age groups being those that provide a greater amount of observation period. The calendar time location point estimate obtained from the weighted average of the different time locations is 1985 for an MMR of 448 per 100 000 live births.

During 1991–1993 there were 40 maternal deaths recorded at the district hospital. The main causes of maternal deaths were sepsis (35%), haemorrhage (17.5%) and rupture of the uterus (12%) (Table 3).

Discussion

In the Kilombero district, one in 40 women who survive until reproductive age will die of maternal causes before age 50. The maternal mortality level provided is twice the Tanzanian

government's estimate for the entire Morogoro region or those derived from the Health for All monitoring exercises (209 maternal deaths per 100 000 live births). However, this estimate is much lower than WHO and UNICEF's proposed value for 1990 (Table 1).¹⁷ Similarly, the Adult Morbidity and Mortality Project (AMMP) in Tanzania provides a higher MMR for the Morogoro region for 1992–1995 (977 deaths per 100 000 live births).¹⁸ The differences in results from a longitudinal study and those using an indirect method to derive estimates can have various causes: (1) Kilombero district may have a different maternal mortality from the rest of the region. This is supported by two circumstances, firstly the coverage of maternal and child health preventive activities in the district is recognized as one of the highest in the country and secondly, the district hospital has benefited from considerable international aid through Swiss co-operation and is considered one of the best reference hospitals in the area. (2) Our results may underestimate the MMR value,

Table 3 Number and percentage of maternal deaths by cause. St Francis District Hospital data, 1991–1993

Cause of maternal death	N (%)
Puerperal sepsis	14 (35%)
Haemorrhage	7 (17%)
Rupture of uterus	5 (12%)
Eclampsia and other hypertensive disorders	4 (10%)
Anaesthetic accident	2 (5%)
Others	9 (22%)
Total	40 (100%)

possibly because of an elevated total fertility rate. (3) Though results derived from a longitudinal study, such as the AAMP study,¹⁹ are expected to have increased precision, the birth rates used to calculate the MMR were not derived from the AAMP study. These were obtained from Tanzanian official estimates, with possibly underestimated figures. This could erroneously increase the MMR. The great variability documented appears to be caused by imprecise estimations with wide CI, partially incomplete data sources, hospital mortality data or denominator problems.

The sisterhood method has been validated in different countries and by several authors,^{20,21} but it is considered a second line method for estimation of MMR. Advantages for its use in this setting is that it is relatively cheap and feasible to obtain²² and is useful for small areas where specific health information may not exist, such as the Kilombero valley. Furthermore it accounts for sampling variability and quantifies it through CI, which is an asset for the reliability of the estimates. Greenwood²³ considers its validity at least as good as other methods available and it does not suffer from denominator bias²⁴ since the fertility rate is obtained from the same survey.

Results of the sisterhood method have been proved to be fairly good when compared with those derived through longitudinal surveys. For example, in Mwanza, Tanzania, comparison of the MMR derived from a prospective community-based survey, the sisterhood method survey, and hospital data, showed that the sisterhood method was fairly close to the prospective community-based survey.²¹

Data from hospital records reveal causes of death very similar to those in other areas in Tanzania. Leading causes of maternal death in developing countries include obstetric haemorrhage and sepsis. In our setting, as well as in other Tanzanian hospital-based studies, sepsis is the first cause of maternal death in hospital. This is possibly associated with the fact that sepsis is found to be high when the level of maternal death is also very high²⁵ or a manifestation of the HIV epidemic, though the prevalence of HIV at that moment is unknown. It is possible, however, that the use of hospital data may be underestimating several causes of maternal deaths since the fraction of births that take place in a hospital setting is low, approximately 30%. Emergency complications, such as haemorrhage, from which women die quickly, or those that occur early in pregnancy, such as those from ectopic pregnancy, may be underrepresented, as well as important indirect causes of maternal death such as malaria. Hospital-based studies in Tanzania describe similar causes of maternal death, i.e. sepsis, haemorrhage and ruptured uterus.^{26–28} Additionally, abortion appears to be another important cause in Tanzanian and quite so in Morogoro region. Data on this cause are quite difficult to obtain, and their importance is underestimated since abortion is illegal in Tanzania.^{18,29,30}

In view of the limited sources of data on maternal deaths in the developing countries, community-based estimates of maternal mortality remain a priority. The sisterhood method is useful in these types of situations in which conventional information is inadequate. Our estimates suggest that maternal mortality remains high implying that it should remain a priority issue in the development of health policy for the district and provide guidance for public health interventions, sensitizing policy makers and programme planners to the magnitude of the problem. They should help to mobilize district, regional, national

and international resources for the Maternal Health and Safe Motherhood programme. These estimates, although referring to events in the past, are considered by the regional health authorities as a cost-effective approach compared to the maintenance of a Demographic Surveillance System in a remote and rural area of sub-Saharan Africa. Therefore, in the absence of other information it could be useful to guide the evaluation of public health initiatives in the community.

Acknowledgements

We thank F Lwilla (District Medical Officer) for his continuous support in the work carried out over the last years in Ifakara. We would also like to acknowledge comments and suggestions from R Genova of the National Health School of Madrid. The staff at the Ifakara Health Research and Development Centre and the district medical team as well as the staff at St Francis Designated District Hospital were central to the success of this work. Funding was provided through grants of the Spanish Agency for International Co-operation (AEI, Ministry of Foreign Affairs, Madrid).

References

- ¹ Sai FT, Measham DM. Safe Motherhood Initiative: getting our priorities straight. *Lancet* 1992;**339**:478–80.
- ² Abou Zahr C, Royston E. The global picture. In: *Maternal Mortality. A Global Factbook*. Geneva: World Health Organization WHO/MCH/MSM/91.3, 1991, pp.3–15.
- ³ Abou Zahr C. Maternal mortality overview. In: Murray CJL, Lopez AD (eds). *Health Dimensions of Sex and Reproduction. Global Burdens of Disease and Injury Series*. Harvard School of Public Health, 1998, pp.111–59.
- ⁴ Salanave B, Bouvier-Colle MH, Varnoux N, Alexander S, MacFarlane A. Classification differences and maternal mortality: a European Study. MOMS Group. *Int J Epidemiol* 1999;**28**:64–69.
- ⁵ Bouvier-Colle MH, Varnoux N, Costes P, Hatton F. Reasons for under-reporting of maternal mortality in France, as indicated by a survey of all deaths of women of childbearing age. *Int J Epidemiol* 1991;**20**:717–21.
- ⁶ Centers for Disease Control. Enhanced maternal mortality surveillance—North Carolina 1988 and 1989. *MMWR* 1991;**40**:469–71.
- ⁷ Campbell O. *Measuring Progress in Safe Motherhood*. Presentation at the Safe Motherhood Technical Consultation in Sri Lanka, 1993, pp.18–23.
- ⁸ WHO and UNICEF. *The Sisterhood Method for Estimating Maternal Mortality: Guidance Notes for Potential Users*. Geneva: WHO, October 1997.
- ⁹ United Republic of Tanzania. *The 1988 Population Census*. Bureau of Statistics, President's Office, Planning Commission, Dar es Salaam, 1991.
- ¹⁰ UNICEF. *The Progress of Nations*. UNICEF, PL & A, Oxfordshire, UK, 1996.
- ¹¹ World Bank. *World Development Report 1993. Investing in Health*. New York: Oxford University Press, 1993.
- ¹² Font F. *Evaluation of the Health Management Information System in the Kilombero District—Morogoro Region*. Memo Document. Hospital Clinic Provincial, Medicus Mundi Catalunya, 1997. (Unpublished document.)
- ¹³ Tanner M, De Saigny D, Mayombana C *et al*. Morbidity and mortality in Kilombero, Tanzania, 1982–88. In: Feacham RG, Jamison DT (eds). *Disease and Mortality in Sub-Saharan Africa*. Oxford: Oxford University Press, 1991, pp.286–305.
- ¹⁴ Graham W, Brass W, Snow R. Estimating maternal mortality: the sisterhood method. *Stud Fam Plann* 1989;**20**:125–33.

- ¹⁵ Ebrahim GJ. Front-line epidemiology. *J Trop Pediatr* 1991;**37**:146–49.
- ¹⁶ Hanley JA, Hagen C, Shiferaw T. Confidence interval and sample size calculations for the sisterhood method of estimating maternal mortality. *Stud Fam Plann* 1996;**27**:220–27.
- ¹⁷ WHO/UNICEF. *Revised 1990 Estimates of Maternal Mortality. A New Approach by WHO and UNICEF*. Geneva: WHO, April 1996.
- ¹⁸ The United Republic of Tanzania Ministry of Health. *Policy Implications of Adult Morbidity and Mortality. End of Phase One Report*. Dar es Salaam: Mark Printers, 1997.
- ¹⁹ Thuriaux M, Lamotte JM. Maternal mortality in developing countries: a note on the choice of denominator. *Int J Epidemiol* 1985;**14**:485–86.
- ²⁰ David P, Kwar S, Graham W. Estimating maternal mortality in Djibouti: an application of the sisterhood method. *Int J Epidemiol* 1991;**20**: 551–57.
- ²¹ Walraven GEL, Mkanje RJB, Van Roosmalen J, Dongen PWJ, Dolman WMV. Assessment of maternal mortality in Tanzania. *Br J Obs Gyn* 1994;**101**:414–17.
- ²² Graham WJ. Maternal mortality: level trends and data deficiencies in disease and mortality in sub-Saharan Africa. In: Feacham RG, Jamison DT (eds). *Disease and Mortality in Sub-Saharan Africa*. Oxford: Oxford University Press, 1991, pp.286–305.
- ²³ Greenwood A. *The Farafenni Project*. Presentation at the workshop on Guidelines for Safe Motherhood Programming. Washington DC: The World Bank/Mothercare, November 1991, pp.17–21.
- ²⁴ Thuriaux M, Lamotte JM. Maternal mortality in developing countries: a note on the choice of denominator. *Int J Epidemiol* 1984;**13**:246–47.
- ²⁵ Vidyasagara NW. *Maternal Services in Sri Lanka*. Paper presented to the Tenth Asian and Oceanic Congress of Obstetrics and Gynaecology, Colombo, 1985.
- ²⁶ Murru M. Hospital maternal mortality in Tanzania. (Unpublished dissertation), 1987.
- ²⁷ World Health Organization. New estimates of maternal mortality. *Wkly Epidemiol Rec* 1991;**66**:345–48.
- ²⁸ Mbaruku G, Bergström S. Reducing maternal mortality in Kigoma, Tanzania. *Health Policy Plann* 1995;**10**:71–78.
- ²⁹ Price TG. Preliminary report on maternal deaths in the Southern highlands of Tanzania in 1983. *J Obs Gyn E Central Afr* 1984;**3**: 103–10.
- ³⁰ Mtimavalye LAR *et al.* Survey on institutional maternal deaths in four regions of Tanzania, July–December 1984. Preliminary Report. In: *Interregional Meeting on the Prevention of Maternal Mortality*. 11–15 November 1985.